The object of this invention is a process and a device for measuring the level of liquid in a tank. It applies, in particular, to measuring the level of oil in the oil tank of a motor vehicle engine, with a "hot wire" of type sensor.

Measuring the oil level using a "hot wire" consists of placing a resistive wire in the oil tank, the immersed length of which depends on the oil level in the tank, or case. A constant-current is applied to this wire for one time period (dt) and the voltage (Us) at the wire terminals is measured, before the application of the constant-current, (Us0), and after application of this current for the time period (dt, Usdt). Because of the rise in temperature due to the Joule effect, especially on the exposed part of the wire, the resistance of the wire varies and the voltage (Us) changes during the time period (dt), according to the oil level in the tank.

Documents FR 86 08 056, EP 249,521 and US 5,272,919 disclose various embodiments of oil level measuring devices using this principle.

The implementation of the principle mentioned above implies cost and complexity to implement due to the necessity of generating a constant-current with a high degree of accuracy (± around one percent).

This invention seeks to remedy these disadvantages by controlling the average current in the resistive wire by using a current generator with a variable cyclic ratio and a probe to measure the average current generated by the generator.

For this purpose, this invention envisages a device for measuring the level of liquid in a tank, comprising a resistive electric wire in thermal contact with the liquid, over a period of time which varies depending on the level of liquid in the tank, characterized in that it comprises:

- a means to measure the current placed in series with the aforementioned resistive electric wire and to provide a signal representative of the current crossing through the aforementioned electric wire,
- a current generator with variable cyclic ratio which applies a current to a variable cyclic ratio with the aforementioned resistance of measurement in series with the aforementioned resistive electric wire, for one predetermined time period (dt),

- a means of control over the cyclic ratio of the current delivered by the current generator, according to the signal provided by the means to measure the current, and
- a circuit to measure the oil level connected at the terminals of the resistive electric wire.

Because of these provisions, the average current passing through the resistive electric wire is precisely controlled, without the power used being expensive or complex.

According to specific characteristics, the means for measuring the current is a precision resistor, the signal provided by the means for measuring the current being the terminal voltage of the aforesaid resistor.

Thanks to these provisions, it is easy to measure the current and has little sensitivity to parasitic signals.

According to specific characteristics, the measurement circuit is associated with an analog-to-digital converter connected at the terminals of the electric wire, the aforementioned converter providing a digital signal representative of the terminal voltage of said resistive electric wire and comprises a microprocessor to receive the aforementioned digital signal. Because of these provisions, control can be performed by a microprocessing calculator in the vehicle which provides other processing functions in the vehicle.

According to specific characteristics, the means of servo-control comprises a second analog-to-digital converter providing a digital signal representative of the terminal voltage of the measurement resistor and a microprocessor which receives the aforementioned digital signal and command, according to aforementioned digital signal, the cyclic ratio of the current delivered by the generator.

Thanks to these provisions, the data at the beginning and the end of the time period (dt) to obtain a measurement of the oil level in the tank may be performed by the vehicle's calculator microprocessor which provides other processing functions in the vehicle.

According to a second aspect, this invention envisages a device for measuring the level of liquid in a tank, implementing a resistive electric conductor in thermal contact with the liquid, over a period of time which varies depending on the level of liquid in the tank, characterized in that it comprises:

- a servo-control stage of a cyclic ratio of the current passing through the aforementioned resistive electric wire, for one time period (dt), according to a signal provided by a means to measure the current placed in series with the aforementioned resistive electric wire, and
- a stage in which the oil level is measured according to the evolution of the voltage to the terminals of said electric wire.

The specific characteristics and advantages of this process which are identical to those of the device briefly disclosed above shall not be mentioned again.

Other advantages, objects and advantages of this invention will appear in the description, given hereafter in reference to the annexed drawings in which:

- Figure 1 shows a device according to one specific embodiment of this invention and
- Figure 2 shows a time series chart of the voltage variation.

In Figure 1, a device (10) for measuring the level of liquid comprises a current generator with variable cyclic ratio (11), a measurement resistor (12), an electric resistive wire (13) which crosses the free surface of the liquid contents (14) in a tank (15), a feedback current circuit (16) connected at the terminals of the measurement resistor (12), a first analog-to-digital converter (17) connected at the terminals of the resistive electric wire (13) and one measuring circuit for the level of liquid (18).

The current generator with variable cyclic ratio (11) is of the known type. The cyclic ratio of the current is controlled by the feedback circuit (16). The measurement resistor (12) is a precision resistor, whose resistance will preferably be disclosed with a margin of less than two percent. The resistive electric wire (13) is of the type known to be used in "hot wire" applications for measuring the level of liquids. Also, the resistive electric wire (13) preferably will have an elevated temperature coefficient, i.e., its resistance will vary according to its temperature. The overall resistance of the resistive electric wire (13) depends on the ratio between the length of the portion making up the electric resistive wire (13) that is submerged, and that is therefore cooled by the liquid, and the exposed portion, which is less cold than the submerged portion.

The feedback current circuit (16) comprises a second analog-to-digital converter (19) connected to the terminals of the measurement resistor and a microprocessor (20) which receives from the second analog-to-digital converter (19) a digital signal representative of the terminal voltage of the resistive electric wire (13) and implements a control program in such a way that the average current voltage strength applied during the measurement phase is a predetermined average voltage strength, independent from the temperature of the engine and/or the oil in the case.

The first analog-to-digital converter (17) provides a digital signal representative of the voltage at the terminal of the resistive electric wire (13). The circuit for measuring the level of liquid (18) comprises a microprocessor (21) which implements a program to measure the oil level according to of the terminal voltage revolution of the resistive electric wire (13), according to known algorithms.

When, for one time period (dt), the generator with variable cyclic ratio (11) applies a current to the resistive electric wire (13) the average strength of which is predetermined, the temperature, the total resistance of the electric resistive wire (13) and the voltage at the terminal of the electric resistive wire (13) changes according to the oil level in the case. The initial voltage is noted as Us0 and the voltage at the end of the dt period is noted as Usdt. By processing the values of Us0 and Usdt, the circuit for measuring the level of liquid (18) determines the oil level and transmits the level of oil measured to a calculator (not shown) in the vehicle which processes this oil level, such as the process for starting the emission of a visual signal on the instrument panel, by lighting up an alarm indicator or displaying a symbol.

It is understood that, with implementation of this invention, the average strength of the current which passes through the electric resistive wire (13) is known, in advance, with a precision which depends on the precision of the value from the measurement resistor (12). Thus, depending on the change in the voltage at the terminal of the electric resistive wire (13), the height of liquid in the case is measured, with a precision corresponding to the precision of the value from the measurement resistor (12).

Alternately, microprocessor 20 and microprocessor 21 are merged in a single microprocessor implementing the program to measure the oil level on the one hand, and the control program on the other hand.

The evolution during the time period (dt) of the various signals implemented in the device shown in Figure 1, can be seen in Figure 2, that is to say, from top to bottom:

- The cyclic ratio control signal (22) emitted by the feedback circuit (16).
- The strength of the current (23) supplied by the current generator with variable cyclic ratio (11),
- The voltage (24) to the terminals of the measurement resistor (12),
- The average voltage (25) to the terminals of the measurement resistor (12) following the beginning of the time period (dt), and
- The voltage (26) to the terminals of the electric resistive wire (13).

For the purposes of simplicity, it was deemed that the time period (dt) in Figure 2 was composed of three successive phases P1, P2 and P3, of equal durations, from the cyclic ratio command signal (22) could only change between two successive phases. However, in reality, the feedback control signal may vary frequently, for example with each cycle of the current generator (11).

It is observed that the periods in which the cyclic ratio command signal (22) and the strength of the current (23) supplied by the current generator (11) are not on the same time scale as the other curves; preferably the duration of a cycle should be several orders of magnitude shorter than the time period (dt). Thus, for each measurement phase, voltage (24) is a virtually linear curve as illustrated in Figure 2.

The voltage (24) at the terminals of the measurement resistor (12) is proportional to the voltage (23) of the current provided by the current generator (11), in accordance with the Joule's law.

Overlapping the average voltage (25) at the terminals of the measurement resistor (12), the average reference voltage (27) is set at the terminals of the measurement resistor (12) which corresponds to the average predetermined target current voltage to be supplied to the electric resistive wire (13).

The goal of the servo system is that at the end of the time period (dt), the average current having passed through the electric resistive wire (13) is as close as possible to the predetermined average voltage which corresponds to the average reference voltage (27); the average reference voltage (27) corresponds to the product of the average predetermined voltage by the resistance of the measurement resistor (12).

At the beginning of the time period (dt) and the P1 phase it was observed that the cyclic ratio control signal has a predetermined value which may depend on the last value of cyclic ratio used during the preceding measurement period. For example, here, the cyclic ratio is from a half cycle.

As illustrated in Figure 2, in the first P1 phase, it is assumed that the average voltage (25) is higher than the reference voltage (27). In this case, at the end of the P1 phase, the feedback circuit (16) lowers the cyclic ratio applied by generator (11) by reducing the value of the cyclic ratio control signal (22).

Thus, during the P2 phase, the cyclic ratio having been lowered in comparison with the cyclic ratio implemented during the P1 phase, the average voltage (25) at the terminals of the measurement resistor (12) decreases gradually.

As illustrated with a broken line in Figure 2, it is assumed that, in the P2 phase, the progressive decrease in the average voltage (25) is, as an absolute value, higher than that corresponding to a convergence of the average voltage (25) with the reference voltage (27). In this case, at the end of the P2 phase, the feedback circuit (16) slightly increases the cyclic ratio applied by generator (11) by slightly increasing the value of the cyclic ratio control signal (22).

Thus, during the P3 phase, the cyclic ratio having been lowered in comparison with the cyclic ratio implemented during the P2 phase, the average voltage (25) at the terminals of the measurement resistor (12) decreases gradually but at a decreasing rate that is much lower than that of phase P2.

Because of the control, carried out here in two stages, the average voltage (25) at the terminals of the measurement resistor is, at the end of the P3 phase, equal to or roughly equal to the reference voltage (27),

which means that the average voltage of the current that has passed through the electric resistive wire (13) is roughly equal to the predetermined voltage.

Thanks to the precision with which the average current voltage is controlled, the initial values (Us0) (at the beginning of the time period (dt)) and the final values (Usdt) (at the end of the time period (dt)) of the voltage at the terminals of the electric resistive wire (13) precisely represent the quantity of the liquid (14) in the tank (15).

The cyclic ratio control function of the difference between the average voltage (25) and the reference voltage (27) is selected to ensure a fast convergence between these two voltages, during the time period (dt). As is understood in the automation field, convergence may be progressive, without exceeding the final value or fluctuating around this final value.

It was observed that the average voltage (27) may depend on the temperature of the oil in the case, thanks to the placement of a temperature gauge (not shown).

Although throughout the entire description, the measurement of the average current voltage passing through the electric resistive wire (13) is taken using a measurement resistor (12), alternately, another means of current measurement may be implemented, for example using a means that is sensitive to the magnetic field generated by the passage of this current through an electric wire put in series with the electric resistive wire (13).

CLAIMS

1] Device (10) for measuring the level of liquid (14) in a tank (15), comprising a resistive electric wire (13) in thermal contact with the liquid, over a period of time which varies depending on the level of liquid in the tank, characterized in that it comprises:

- a means to measure the current (12) placed in series with the aforementioned resistive electric wire and to provide a signal representative of the current crossing through the aforementioned electric wire,
- a current generator with variable cyclic ratio (11) which applies a current to a variable cyclic ratio with the aforementioned resistance of measurement in series with the aforementioned resistive electric wire, for one predetermined time period (dt),
- a means of control (19) over the cyclic ratio of the current delivered by the current generator, according to the signal provided by the means to measure the current, and
- a circuit to measure the oil level (18) connected at the terminals of the resistive electric wire.

2] Measurement device according to Claim 1, characterized in that the means for measuring the current (12) is a precision resistor, the signal provided by the means for measuring the current being the terminal voltage of the aforesaid resistor.

3] Measurement device according to either Claim 1 or 2, characterized in that the measurement circuit (18) is associated with an analog-to-digital converter (17) connected at the terminals of the electric wire, the aforementioned converter providing a digital signal representative of the terminal voltage of said resistive electric wire and comprises a microprocessor (21) to receive the aforementioned digital signal representative of the voltage at the terminals of said electric resistive wire.

4] Measurement device according to any of Claims 1 through 3, characterized in that the means of control (16) comprises a second analog-to-digital converter (19) supplying a digital signal which is representative of the signal supplied by the means for measuring the current and a microprocessor (20) to receive the aforementioned digital signal representative of the signal supplied by the means for measuring the current and controlling, depending upon said digital signal, the cyclic ratio of the current delivered by the generator.

5] Process for measuring the level of liquid (14) in a tank (15), implementing a resistive electric wire (13) in thermal contact with the liquid, over a period of time which varies depending on the level of liquid in the tank, characterized in that it comprises:

- a servo-control stage of a cyclic ratio of the current passing through the aforementioned resistive electric wire, for one time period (dt), according to a signal provided by a means to measure the current (12) placed in series with the aforementioned resistive electric wire, and
- a stage in which the oil level is measured according to the evolution of the voltage to the terminals of said electric wire.

6] Measuring procedure in accordance with Claim 5, characterized in that the measurements stage includes an analog-digital conversion of the voltage at the electric resistive wire's terminals.

7] Measuring procedure according to either of Claim 5 or 6, characterized in that the control stage includes an analog-digital conversion of the signal supplied by the means of measuring the current.